HEAVY PRECIPITATION STORM IN NORTHERN UTAH JANUARY 29 TO FEBRUARY 2, 1963

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ABSTRACT

Record-breaking amounts of precipitation occurred in northern Utah during the period January 29 to February 2, 1963. The synoptic situation associated with this storm is discussed and some of the possible factors involved in the production of heavy precipitation in this area are listed. A brief comparison between the hydrologically critical features of this storm and those of the heavy rain-on-snow storm which occurred in February 1962 is made, and the importance of soil condition in flood production is emphasized.

1. INTRODUCTION

Record-breaking amounts of precipitation occurred in northern Utah from January 29 to February 2, 1963. Several features of this storm and the associated precipitation were very unusual and merit investigation.

During the night of January 31 and February 1, 1963, 5.08 in. of rainfall was measured at Deer Creek Dam in Provo Canyon, Utah. This amount exceeded the previous official 24-hr. precipitation value for Utah of 4.50 in. which has been measured at both Monticello, on November 27, 1919, and at Tropic, on January 23, 1943. A report of over 5.00 in. of precipitation during a 1-day summer storm was obtained from a bucket survey near Morgan, Utah, on August 16, 1958. New official 48-hr., 72-hr., and 96-hr. records for the State were also established. These are 8.88 in., 9.59 in., and 10.13 in., respectively. Undoubtedly, new records for periods shorter than 24 hr. would have been established had recorder measurements been available.

The record-breaking precipitation in 1963 followed by one year a heavy rain storm which caused extensive flooding in northern Utah, eastern Nevada, and southern Idaho. Serious flooding in 1963 repeated the record-breaking flooding in southern Idaho but was limited in Utah to the immediate area of Deer Creek Dam. Concurrent with the 1963 storm in Utah, heavy precipitation occurred over a wide area of northern and central California. Three-day amounts in this area approximated those of the record December 1955 storm.

2. DESCRIPTION OF STORM

The meteorological synoptic situation associated with the heavy precipitation in the 1963 storm was quite different from that of the previous year, as reported by Peck and Richardson [2]. At 700 mb. (fig. 1) a strong blocking *High (omega type)* was centered over Alaska; this persisted during most of the storm period. This high pressure area forced Pacific storms to the south and maintained an on-shore flow of warm moist air. During most of the storm period, strong zonal flow aloft prevailed over the continental United States. A zone of confluence persisted along the west coast, spreading at times over the northwestern section of the Nation. The blocking High began to break down early on the morning of February 1, terminating the features permitting the Utah storm.

The surface synoptic charts during the storm (fig. 2), show a slowly moving polar front lying east-west through central Idaho and Oregon on January 28 which moved southward to the vicinity of Salt Lake City, Utah, by the following day. Early on January 30 a series of minor waves began moving onto the coast from the Pacific low-pressure system. The weak surface fronts associated with these short waves dissipated before reaching northern Utah except for the last one of the series which passed over the northern portion of the State on the morning of February 1.

Radiosonde observations of the upper air are made twice daily at the Weather Bureau Airport Station at Salt Lake City. The adiabatic charts for the storm period show a steady increase in the moisture content of the atmosphere beginning with the January 28 observation (fig. 3). By the morning of January 30, the air mass was nearly saturated from the surface to 400 mb. Except for a slight decrease in moisture below the 700-mb. level, it remained nearly saturated until the afternoon of February 1.

Variations in the temperature soundings were also very interesting. During the afternoon of January 29 marked warming occurred above the 700-mb. level and extended to all levels by the morning of January 30. With this rapid warming, the freezing level rose from the surface to near 9,000 ft., MSL.

During the night of the 30th, additional warming

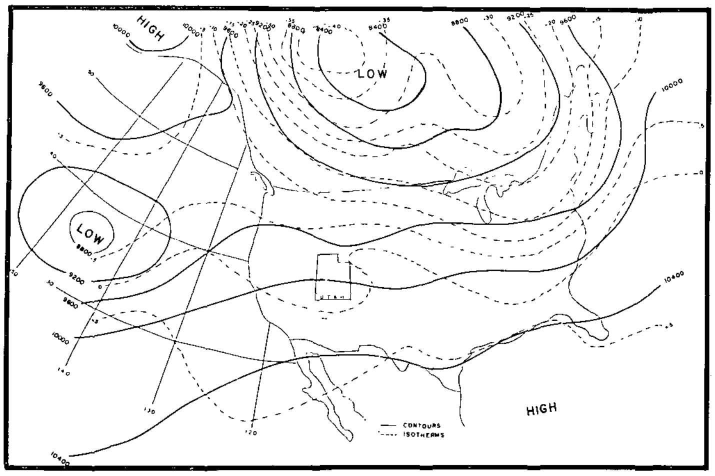

FIGURE 1.—700-mb. chart, 0500 MST, January 31, 1963, showing contour and temperature patterns.

occurred below the 700-mb. level and accounted for the precipitation falling in the form of rain. At the same time, several degrees of cooling occurred above the 500-mb. level, decreasing the stability of the atmosphere. This decrease in stability combined with the lifting effect of the Wasatch Mountains and the funneling exerted by the topography were effective factors in producing the record precipitation at Deer Creek Dam, Utah. The record 5.08 in. occurred principally during two periods: 2200 MST January 31–0100 MST February 1 and 0430–0700 MST February 1. The first period of heavy precipitation was associated with thunderstorm activity; the second probably occurred with the passage of the surface front. By comparison, Salt Lake City Airport, which did not have the added effects of topographic lifting and funneling, recorded only 0.23 in. during the 5-day period.

The 700-mb. chart (fig. 1) for 0500 MST January 31, 1963, shows the moist west-southwesterly flow that prevailed over the western States during the storm period. Minor upper-air waves moved along the general flow pattern and caused variations in the observed precipitation. Poorest weather (clouds and precipitation) is generally found immediately east of minor troughs, and less intense weather as minor ridges approach. Figure 4 shows the 6-hr. winds aloft for Salt Lake City from 5,000 to 23,000 ft. MSL for the storm period, illustrating that the storm was a low-level phenomenon. The upper-air flow at 700 mb. changed from west-southwest to west-northwest with the passage of the upper-air trough and surface front through northern Utah on the morning of February 1. The strongest upper-air winds (110 to 115 kt.) occurred on the morning of February 1 at 20,000 to 21,000 ft. MSL, indicating the proximity of an upper-air jet stream.

A U.S. Navy handbook [3] has shown that a time hodograph may be used to depict the movement of minor perturbations (short waves) along major waves. A time hodograph, using 6-hr. 10,000-ft. MSL winds from the Salt Lake City Weather Bureau Airport Station during the period January 29 to February 1, is shown in figure 5. The winds are plotted by direction and speed, and each point is labeled with the date and time (mountain standard) of the observation. The circular looping indicates that perturbations were moving through the area; each complete loop indicating the movement of an entire minor wave (from a trough, through a ridge, to a trough). If the line connecting consecutive wind vectors moves clockwise, it indicates that the center of the perturbation moving through the area is north of the station. Likewise, a counterclockwise movement locates the center of a perturbation south of a station. Three minor waves moved through the area with centers north of Salt Lake City at approximately 24-hr. intervals on January 30 and 31 and February 1.

The effect of a minor wave passage on precipitation is demonstrated by the plot of 6-hr. precipitation totals for Malad, Idaho (approximately 100 mi. north of Salt Lake City), on the hodograph in figure 3. Precipitation data from Malad, Idaho, were chosen for illustration since the perturbation at Malad occurred when the hodograph loops indicate that the minor wave trough was approaching the station (right-hand section of the three loops). It was not possible to determine the actual distribution of precipitation in the area of Deer Creek Dam, Utah, since there were no recording rain gages. The movement of the short waves across the area of Deer Creek Dam must have had an influence on the time distribution and total amount of precipitation produced.

A survey by Weather Bureau personnel was conducted on February 2 in the region of heaviest precipitation to obtain personal accounts of the storm and measurements or estimates of heavy precipitation. These reports confirmed that the area of heaviest precipitation was limited to the immediate area of Deer Creek Dam. At the Conrad Ranch (fig. 6) on the South Fork of the Provo River, Mr. Conrad used fruit juice cans to catch rainfall for his own information. The total catch as checked by Weather Bureau personnel was 7.00 in. The survey also brought out the fact that thunderstorm activity occurred during the storm. Light snow fell in Provo Canyon on January 29, but changed to rain by nightfall. The rain was reported as steady through February 1, forenoon. The lower valleys and hillsides up to 7,500 ft. MSL were quickly denuded of snowcover.

The survey produced additional estimates of the total storm precipitation. One of the most interesting accounts of the severity of the storm was the report given by Don Wimpie, the weather observer at the Deer Creek Dam, as stated below:

"Clouds were very dense during the entire period. There was a strong up-canyon wind (from the southwest) which at times was as strong as any we have encountered in this canyon, but in the opposite direction of the pre-

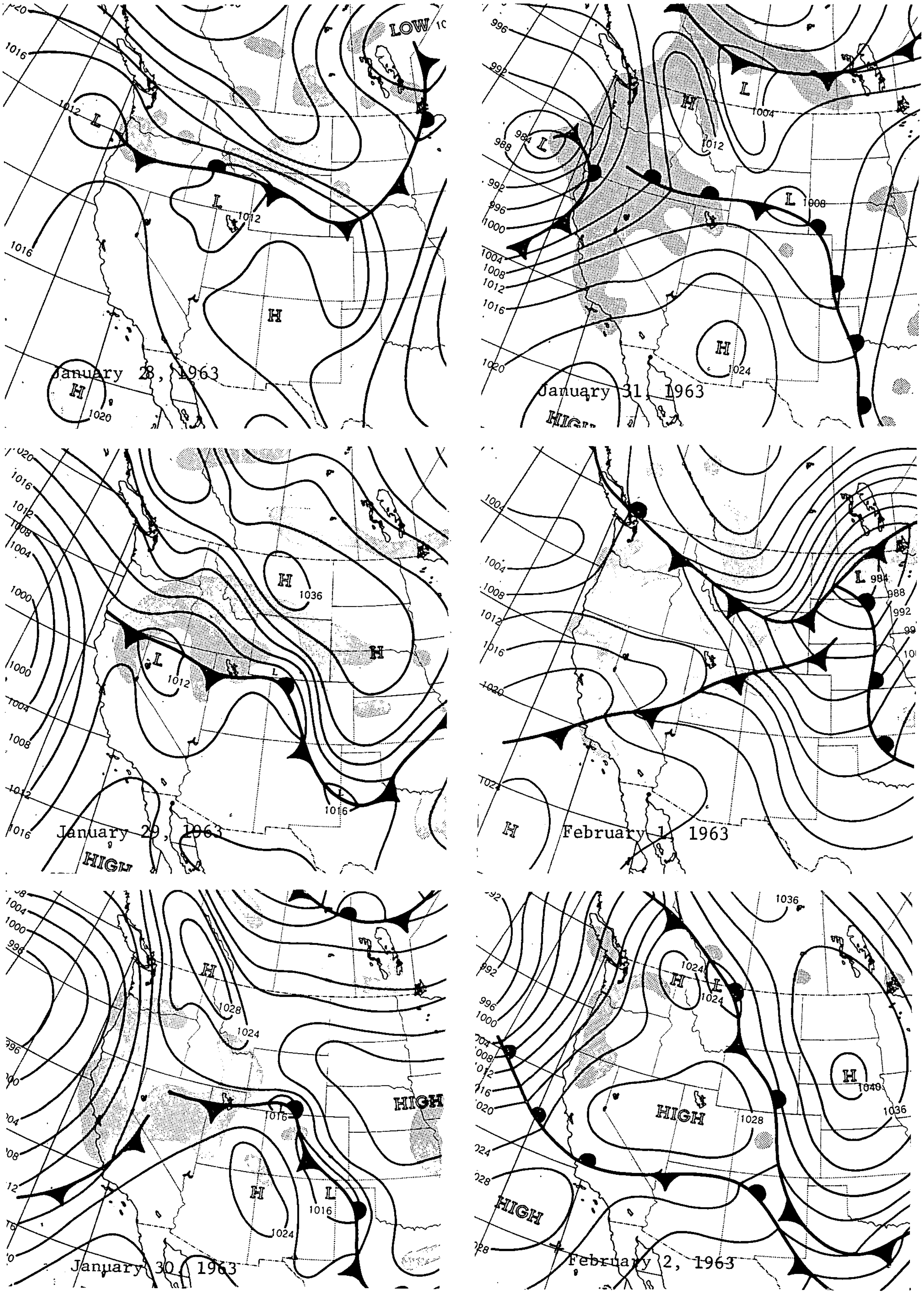

FIGURE 2.—Surface weather maps, 1100 MST, January 28 through February 2, 1963, showing synoptic situations which lead to record-breaking precipitation at Deer Creek Dam, Utah.

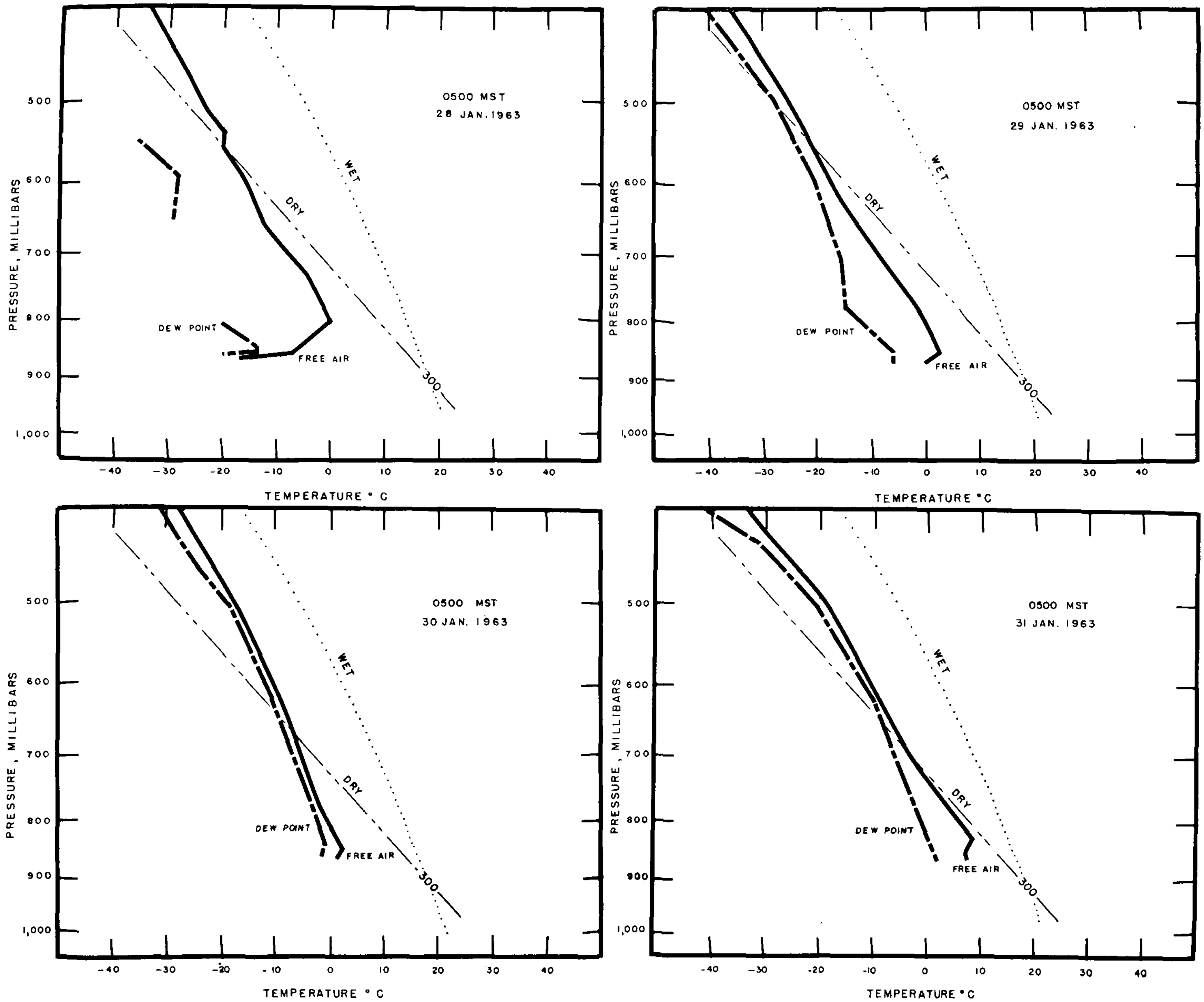

FIGURE 3.—Adiabatic charts for Salt Lake City, Utah, for period prior to maximum storm.

vailing wind. Rain was so heavy that one could see only a few rods at the most even during the middle of the day. We observed at last two streaks of lightning but heard no thunder in the power station. Rain came down in the proverbial sheets with the heaviest period from 10:00 p.m. to 1:00 a.m. on Thursday night, and again from 4:30 a.m. to 7:00 a.m. on Friday, February 1. This was the period when a large percentage of the 5.08 in. probably occurred, although rain was practically continuous during the 4-day period. Rain was seeping through the cinder-block wall on the west side of the power house and required continual mopping up. The Friday morning measurement of 5.08 inches was so unusual that we called all four employees on duty to check on the amounts, which required three fillings of the small measuring tube as follows: 1.80, 1.78, and 1.50. This precipitation was also preserved in a separate container and later rechecked by our supervisors from the Provo River Water Users Company in Provo. Height of the water in the reservoir had risen 3.2 ft. at the 9:00 a.m. (Saturday) check-out and was expected to rise further as the moisture drained down from the rain-soaked hills. One unusual aspect noted and photographed was the many mud slides scarring the grassy hill sides north of the dam, away from the highway. Only minor traffic interference was reported on the main highway which skirts the southern side of the dam."

Isohyetal maps were prepared for the 5-day storm period and for the 24-hr. period of maximum precipitation at Deer Creek Dam. A plotting of the ratios of the

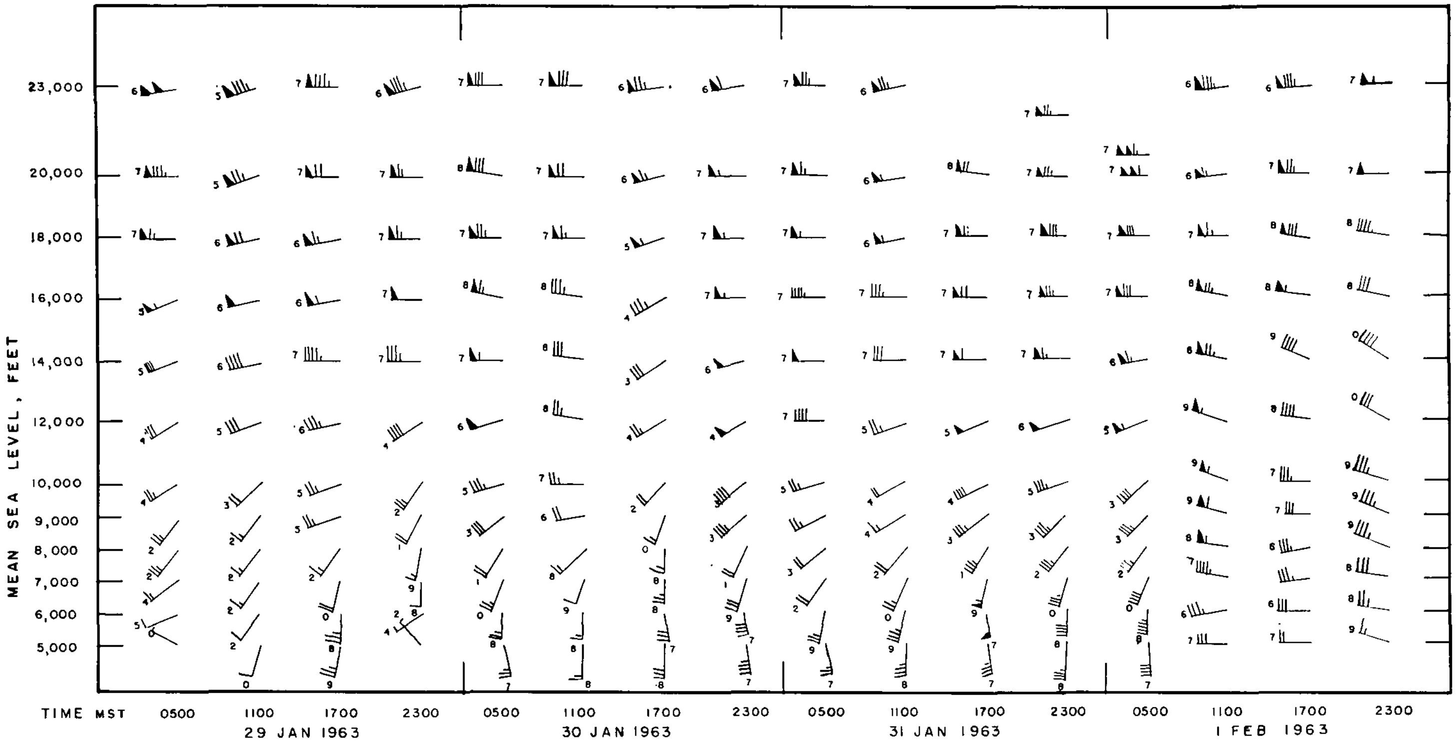

FIGURE 4.—Winds aloft, 6-hr. interval, Salt Lake City, Utah, January 29 to February 1, 1963.

24-hr. precipitation totals to the 5-day totals showed a consistent pattern and was used to derive estimates for the 24-hr. isohyetal map for locations where only storm totals were available (shown in parentheses on fig. 6). An isohyetal map for the general area surrounding Deer Creek Dam for the 24-hr. period when the record-breaking total of 5.08 in. was measured is shown on figure 6. The most unusual feature of the map is that the highest-valued isohyets are east of the major ridge of the Wasatch Front, although with westerly winds aloft the heaviest precipitation is generally found on the western slopes. A similar distribution of precipitation with topography for a major storm in California has been reported by Weaver [4]. This same condition prevailed to the south along the extension of the Wasatch Mountains in central Utah. Stream-gaging chart records and other information furnished by the Salt Lake City District Office of the U.S. Geological Survey were used to help locate the areal extent of the heavy precipitation for the 24-hr. isohyetal map.

Table 1 is a tabulation of the precipitation of selected stations showing the total amount observed for the 5-day period, the amount for the 24-hr. period when the record breaking total was observed at Deer Creek Dam, and the maximum 24-hr. total reported for each station during the storm.

3. METEOROLOGICAL ASPECTS OF THE STORM

The record-breaking precipitation associated with the storm and the unusual distribution of the precipitation pose questions for which there are no definite meteorological answers. Considerable research beyond the scope of the present study would be required to provide the answers. However, in view of the importance of such record-

TABLE 1.—*Tabulation of total and 24-hr. amounts of precipitation January 29–February 2, 1963, for selected stations in vicinity of Deer Creek Dam, Utah*

Station	Precipitation Jan. 29–Feb. 2, 1963 (in.)	Precipitation during 24-hr. period of maximum precipitation at Deer Creek Dam (in.)	Maximum 24-hr. precipitation at station during storm (in.)
Alpine	1.55	0.25	0.68
Bartholomew	3.68	0.40	1.34
Big Cottonwood Weir	0.29	0.08	0.13
Coalville	1.87	0.63	0.98
Deer Creek Dam	10.13	5.08	5.08
Echo Dam	1.16	0.64	0.64
Geneva	1.18	0.12	0.53
Heber	4.48	1.55	2.02
Kamas	2.16	0.14	0.90
Mt. Dell	1.13	0.30	0.39
Olmstead Power House	2.35	0.31	1.12
Pleasant Grove	1.39	0.22	0.35
Provo	1.63	0.40	0.62
Salt Lake City Airport	0.23	0.15	0.15
Silver Lake Brighton	4.78	1.26	1.64
Snake Creek	5.56	1.97	2.53
Spanish Fork, 1 S	0.92	0.24	0.41
Spanish Fork Power House	1.11	0.25	0.49
Strawberry Heights	3.94	1.61	1.61
Timpanogos Cave	3.68	0.43	2.25
University of Utah	0.24	0.11	0.11
Upper American Fork	2.50	0.24	1.21
Utah Lake	1.16	0.15	0.57
Wanship Dam	1.63	0.70	0.70

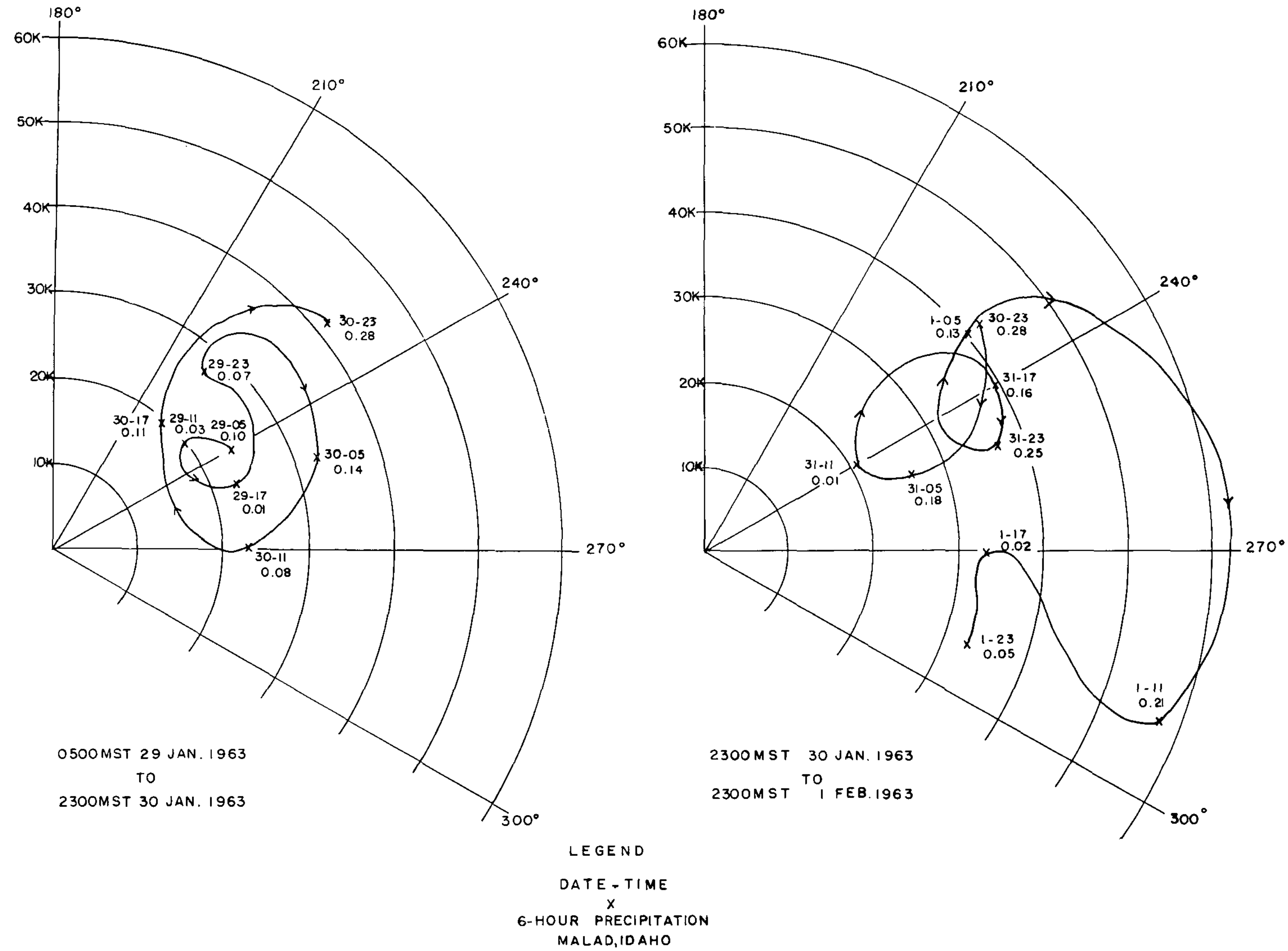

FIGURE 5.—Time hodograph for storm period. 6-hr. 10,000-ft. MSL winds, Salt Lake City, Utah.

breaking storms to hydrology, a list of some of the possible factors involved in the production of the heavy precipitation is given below:

1. A considerable portion of the heavy precipitation was probably associated with the passage of short waves. The largest 24-hr. total occurred with the passage of a surface frontal system associated with a strong upper-air trough.

2. Orographic lifting played an important part in determining the precipitation distribution since the air mass was fairly stable and moist in the lower layers during the entire storm period.

3. The upper-air jet stream apparently moved over the area of Deer Creek Dam, Utah, during the period of heaviest precipitation (cf. [1]).

4. The temperature changes in the vertical indicated the development of instability aloft near the end of the storm period. Colder air could have moved in above warm moist air in Heber Valley preceding the passage of the surface trough. This would have induced considerable instability during the 24-hr. period when maximum precipitation was observed. The reported thunderstorm activity tends to verify the instability. Topographic funneling brought warm moist air into Heber Valley from the southwest during the entire period.

5. The wind direction, prior to the passage of the major trough, from the surface to approximately 7,000 ft. MSL over the Salt Lake Valley, was southerly and parallel to the Wasatch Mountain ridge. At 8,000 ft. MSL winds were generally southwesterly and shifted to westerly or perpendicular to the average ridge of the mountains at 14,000 ft. MSL. This wind pattern produced minor lifting of the moist air mass on the western slopes but from the precipitation distribution pattern apparently resulted in strong lifting just east of the major mountain ridge line.

6. Surface dew points in Nevada and Utah on January

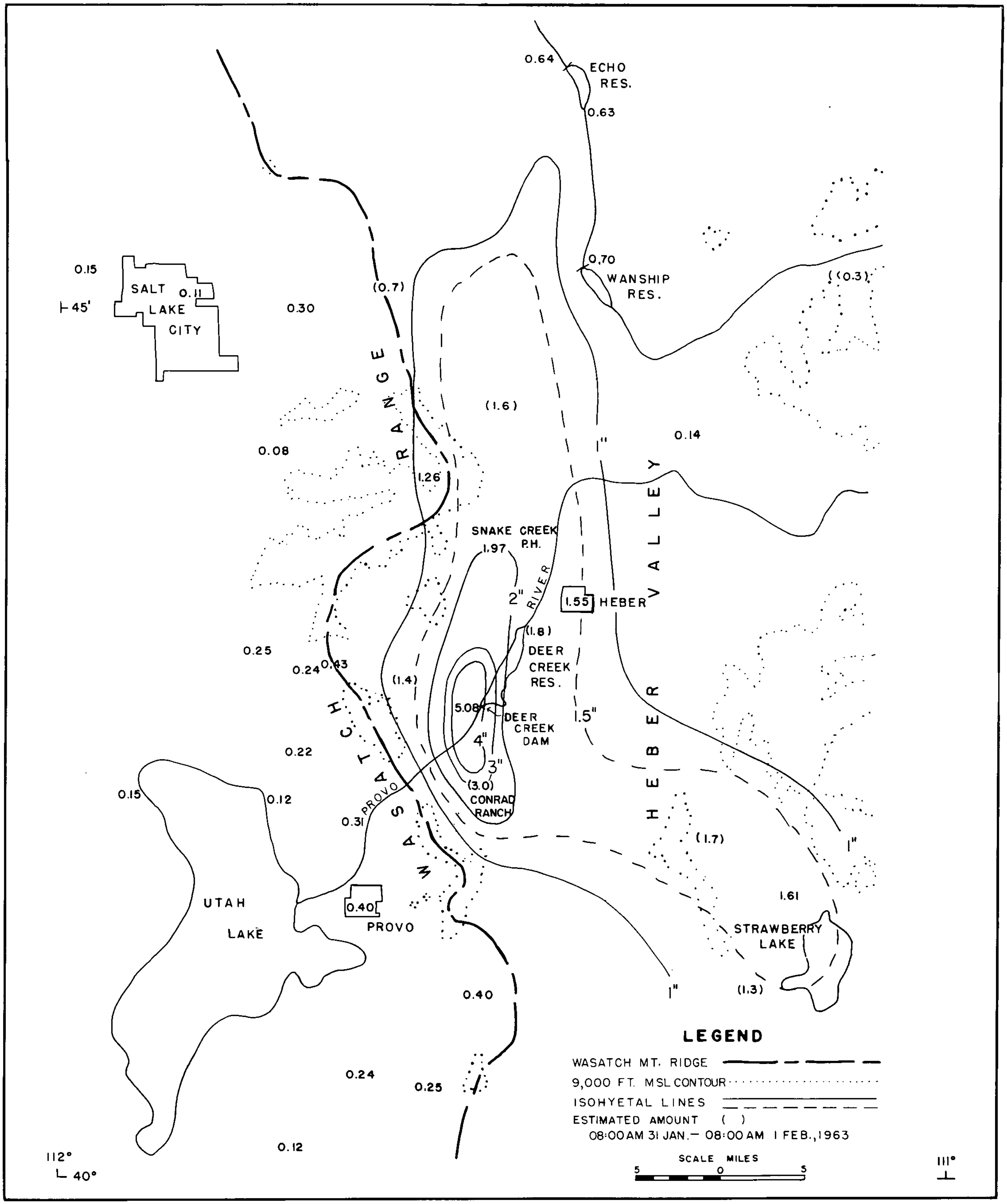

FIGURE 6.—24-hr. isohyetal map for record-breaking precipitation in vicinity of Deer Creek Dam, Utah.

31, 1963 approached record 12-hr. highest persisting values for the month.

4. COMPARISON OF HYDROLOGICALLY CRITICAL FACTORS WITH THOSE OF FEBRUARY 1962 STORM

The rain-on-snow storm which occurred in February 1962 resulted in heavy flooding in northern Utah and eastern Nevada. However, flooding during the 1963 storm was limited to the immediate area of Deer Creek Dam, Utah.

Climatic conditions preceding the two storms show a very marked difference. Precipitation during the fall of 1961 was much above normal, while for the fall of 1962, it was much below. At Heber, Utah, which is located in the Heber Valley where major flooding occurred in 1962, 10.64 in. of precipitation were observed from September 1, 1961, to February 1, 1962. From September 1, 1962, to the storm period in 1963, there were only 19 days with measurable precipitation and the total amount was 2.09 in.

Differences in snow cover were just as marked. During the 1961–62 season, Heber, Utah, had continuous snow cover from November 16 through February 16 with a maximum depth of 19 in. The only appreciable snow cover during 1962–63 occurred during January 14–31.

Temperatures were much lower during the 1961–62 season with a total of 1,014 accumulated freezing-degree days (Peck and Richardson [2]) between September 1 and February 1. For the 1962–63 season there was an accumulation of only 300 freezing-degree days.

As a result of the differences in the amount of precipitation, snow cover, and temperatures, the condition of the soil for the two seasons was quite different. The ground was frozen to a depth of approximately 3 ft. during the 1961–62 season with a dense concrete type of frost. This type of frost is highly impermeable and considerable heat is required for its dissipation. In 1962, it was not permeated for two or three days during the storm period and this resulted in exceptionally heavy surface flow. The frost during the 1963 storm was reported as fairly deep in the Salt Lake Valley (26 in.), but was of a honey-comb or hoar type due to the dryness of the ground. This type of frost actually may increase infiltration and requires less heat than the concrete type for dissipation. Thus during the 1963 storm, most of the water available for runoff was taken into the ground and very little flooding resulted. Water available for flooding, as estimated for Heber and Snake Creek Power House, Utah, located in the Heber Valley, is shown in table 2. Considerably more water was available from rain and snowmelt during the 1963 storm period, when flooding was very limited.

On February 9–10, 1962, both the 12-hr. and 24-hr. highest persisting dew point records were tied at the Salt Lake City Weather Bureau Airport Station (41° F.). During the 1963 storm, the 12-hr. highest persisting dew point was 39° F., or 2° lower at the same station.

Table 2.—*Tabulation of precipitation and estimated available water, Heber Valley, Utah*

Station	Elevation (ft.)	Dates of Storm	Precipitation 30 days prior to flood (in.)	Precipitation during flood period (in.)	Estimated total available water (in.)
Heber	5,593	Feb. 8–12, 1962	2.60	1.15	3.50
		Jan. 29–Feb. 2, 1963	0.44	4.56	4.90
Snake Creek Power House.	5,950	Feb. 8–12, 1962	3.02	2.16	5.00
		Jan 29.–Feb. 2, 1963	0.86	5.75	6.50

Table 3.—*Rain storms of over 1.00 in. on consecutive days during January and February in the last 70 years at Heber, Utah*

Year	Storm period	Total precipitation (in.)
1906	January 17–19	1.83
1918	February 22–24	1.07
1922	January 2–3	1.25
1932	February 6–9	1.92
1937	February 6–7	1.77
1962	February 8–12	1.15
1963	January 29–February 2	4.56

5. COMPARISON WITH OTHER YEARS

Precipitation in the form of rain has fallen at Heber, Utah, in January or February or during both months during 33 out of the 70 years since climatological records began. Snow depth records are not complete for the entire period and it is not possible to determine the number of times rain has fallen on a snow cover or the total amount of water which would have been available for flooding as was done in table 2 for 1962 and 1963. However, in 7 out of the 70 years of record accumulated precipitation (at least part in the form of rain) for consecutive days exceeded 1 in. (table 3). No records of flooding conditions are available for Heber, Utah, and no account of serious flooding could be found in the files of the Deseret News of Salt Lake City, Utah, covering the entire period. The 1962 flood is recognized by the old timers contacted as being the worst in the history of the city. As indicated by Peck and Richardson [2], serious flooding in the Heber Valley requires not only unusually heavy rain but frozen wet soil. The frozen wet soil requires an unusual set of climatological events: a wet fall, very cold weather with little or no snow cover, and no thawing until the flooding period. It would be very difficult to place a frequency on the simultaneous occurrence of all these events such as occurred in 1962.

ACKNOWLEDGMENTS

The authors wish to acknowledge the assistance of Mr. Elven S. McDonough in making the bucket survey, and the cooperation of all those who supplied information on the storm.

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2. E. L. Peck and E. A. Richardson, "An Analysis of the Causative Factors of the February 1962 Floods in Utah and Eastern Nevada," *Monthly Weather Review*, vol. 90, No. 9, Sept. 1962, pp. 407–413.
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4 R. L. Weaver, "Meteorology of Hydrologically Critical Storms in California," *Hydrometeorological Report* No. 37, U.S. Weather Bureau, Washington, D.C., December 1962, 207 pp.

[*Received October 24, 1963; revised January 27, 1964*]

CORRECTION

Monthly Weather Review, vol. 92, May 1964:

p. 211, col. 1: Last sentence before section 4 should read "Hilo's *second* highest morning count, 488," etc.

p. 212, table 4: Caption should read "Median number of ice crystals *and of dust particles*" etc. A second row should be added to the table as follows:

	a.m.	p.m.	a.m.	p.m.
Dust particles	400	280	218	238

p. 217, last sentence in last complete paragraph in col. 2 should read: "On both occasions, the possibility that nuclei from higher aloft may have been involved in the increase at MLO, which preceded by a day that at Hilo, is somewhat discounted by the fact that counts at the Observatory were less than a tenth those at Hilo."